National Aeronautics and Space Administration

NASA

TEACHER ACTIVITY MANUAL

MISSED MESSAGES

This activity challenges students to convey data from one side of a room to another. The task starts easy, but gets progressively harder as restrictions are added. The activity shows the needs and constraints of space communications while stretching the engineering imagination of participants.

AGE	SIZE	COST	TIME
10+	6-18 STUDENTS	<$30	30-45 MIN

LEARNING OBJECTIVES

NEXT GENERATION SCIENCE STANDARDS

Performance Expectation: 1-PS4-4

DCI: PS4.C: Information Technologies & Instrumentation
People use a variety of devices to communicate (send and receive information) over long distances.

Performance Expectation: 4-PS4-3

DCI: PS4.C: Information Technologies & Instrumentation
Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.

DCI: ETS1.C: Optimizing the Design Solution
Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Performance Expectation: MS-PS4-2

DCI: PS4.A: Wave Properties
A sound wave needs a medium through which it is transmitted.

DCI: PS4.B: Electromagnetic Radiation
The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

VOCABULARY

DATA: Important facts or information.

ENCODING: Translating data from a human-understandable language to computer language.

DECODING: Translating data from computer language back to human-understandable language.

TRANSMIT: To send out or pass on information.

RECEIVE: To hear or 'catch' information.

ATMOSPHERE: The literal ball of air that is drawn to Earth's surface by gravity.

VACUUM: Empty space with nothing in it.

SPACECRAFT: Anything made by humans that leaves Earth's atmosphere and goes into space.

ORBIT: To fly around a celestial object in a regular, repeating pattern.

SATELLITE: Anything that orbits a planet/moon/etc. Can be artificial or natural (moons, comets).

ELECTROMAGNETIC SPECTRUM: All the different colors and energies of light and radiation, even ones humans cannot see.

CORE TAKEAWAYS

- The physical realities of space create many barriers to communication.
- Running a wireless network is challenging; running a space internet over vast distances, between moving planets, is even more challenging.
- NASA engineers have used clever thinking and hard work to overcome these problems.

PREPARATION

MATERIALS

1. Large whiteboard or easel
2. Masking tape, chalk or ropes to mark zones
3. Printed Morse code cheat sheet
   Morse code guide on pg. 7.
4. Printed graphics:
   - Earth
   - Relay satellites (2)
   - Spacecraft (2)

   Example graphics on pg. 7.
5. Markers
6. Index cards
7. Line-of-sight blockers
   (a curtain, cardboard panel or easel)
8. Laser pointers or flashlights
   (minimum one per team)
9. Hand mirrors

OPTIONAL

1. String and cups for string-can telephones
2. Heavy cardstock for paper airplanes
3. Other random items, either as red herrings or to spark creativity
4. Telegraph keys, beepers or anything that can be used with Morse code
5. Small dental mirrors
6. Telescope / binoculars
7. Radios (walkie talkies, smartphones)
8. Spinning chairs (for planetary motion)

CONSTRUCTION

1. Make a deck of index cards of three- and four-letter words to transmit. If you have enough floor space and participants for teams, make a deck for each team.
   Sample words on pg. 6.
2. Set up zones:
   - At one end of the room, mark a circle approximately five to six feet in diameter on the ground. This will be your "Earth."
   - Make zones for "Spacecraft" and for "Relays." Each team should have its own Spacecraft and Bouncer, but all teams share Earth.

     Diagram on pg. 7.
3. Set out a pad of paper, pens and the printed signs at each station.
4. Have your box of secondary items near but off limits. These will be 'unlocked' as students progress.
5. Have your line-of-sight blockers available but out of the way.
6. Write "RESTRICTIONS" at the top of the whiteboard/easel where all groups can see it. Alternately, prepare cards with restrictions already written on them.
   Restrictions listed on pg. 6.

WARNING: LASERS CAN DAMAGE EYES

Permanent sight damage and incremental blindness can result from exposure to laser light as it burns the back of the eye.

- DO NOT EVER allow anyone else to look directly into the laser source.
- DO NOT EVER allow anyone to point the laser source at or near anyone's face.
- DO NOT EVER reflect the laser beam at or near anyone's face. Even partially reflective surfaces can still bounce harmful amounts of light into the eye.

INSTRUCTIONS

DISCUSS

What is a space communications network?

- Explain that NASA has many instruments out in the solar system, collecting valuable data.
- Show pictures of exciting things from the solar system; ask how those pictures got back home.
- Give examples of missions supported by communications networks.
- Fold in vocabulary definitions from pg. 2.

IMAGINE

What kind of mission are we simulating?

- Orbiter or lander? Is this a manned mission?
- What are we orbiting around, landing on, taking pictures of or scooping up?
- Push participants' research imagination in the direction of scientific goals.

DIVIDE INTO GROUPS

"Spacecraft" - *These are transmitters; you will give them the data (words) to transmit home to Earth.*

"Relay Satellites" - *These are relays; their job is to help get the data home.*

"Earth" - *These are the receivers, scientists on the ground eagerly listening for the data coming back from the spacecraft. Their job is to record the data exactly as they receive it.*

STATE OBJECTIVES

- Their goal is to send data, the three- and four-letter words, from the Spacecraft back to Earth.
- There are no rules yet, but each successful transmission will prompt a new rule.
- Participants may use anything they have with them to get the job done.

ASSIGN ROLES

- Have someone from the Spacecraft group pull a card from your deck of messages. Task the Spacecraft with sending that data home to Earth.
- Task Earth with faithfully recording the message. A team has not finished transmitting their message home until the instructor has seen the message written out and compared to the original.

TRANSMIT & REPEAT

- If the message was too garbled, have them try again. Discuss what's going wrong.
- Once they succeed, add a restriction based on the method the team used. Restrictions are listed in the chart on page six. Add the new restriction to the whiteboard, and then have them pick a new word from the deck.
- Repeat until the group reaches a satisfactory concluding point.
- If groups get stuck or frustrated, help them by unlocking a new technology from the list of optional materials - "People are excited about your mission and Congress has sent more money!"

ASSESSMENT

LCRD

THE GOAL:

The objective of the activity is to have students build up from rudimentary communication to laser pointers and Morse code.

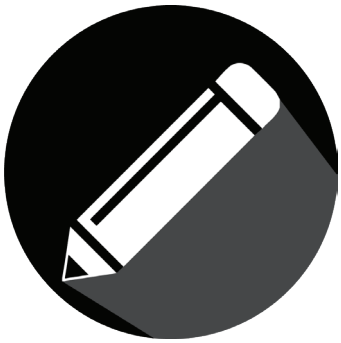
Optical communications, using lasers, is the future of NASA's networks. It can send more data per second and requires less size, weight and power than radio communications. Tell the participants about optical communications missions like the Laser Communications Relay Demonstration (LCRD), which will prove these technologies in space.

Have students reflect on how this might apply to real life. What parallels can they draw to their everyday activities? How might the restrictions and challenges in this activity be relevant to an astronaut preparing for space travel?

Have teams discuss among themselves:

- Why did they chose those solutions?
- What made individual solutions easier or harder?
- What can be done to improve the process?

Present your team's thoughts to the classroom.



Write or illustrate two things learned about communication during this exercise; focus on word choice, listening styles and group dynamics. How would they advise a group about to attempt this activity? Can they collaborate to draw a "communications guide" that uses no words?

What would happen if participants were blindfolded, or had earplugs, or were not allowed to speak? What would change and what would stay the same? How might this provide other opportunities for communication?

TIPS

- Occasionally rotate the groups among the different zones/roles; "Earth" tends to be a dull job.
- Groups tend to focus on the newest tool, so don't release new ones until available solutions are exhausted.
- It may take the teams a bit longer to work out how best to use the laser pointers to communicate, so budget more time for the final stages.

RESTRICTIONS LIST

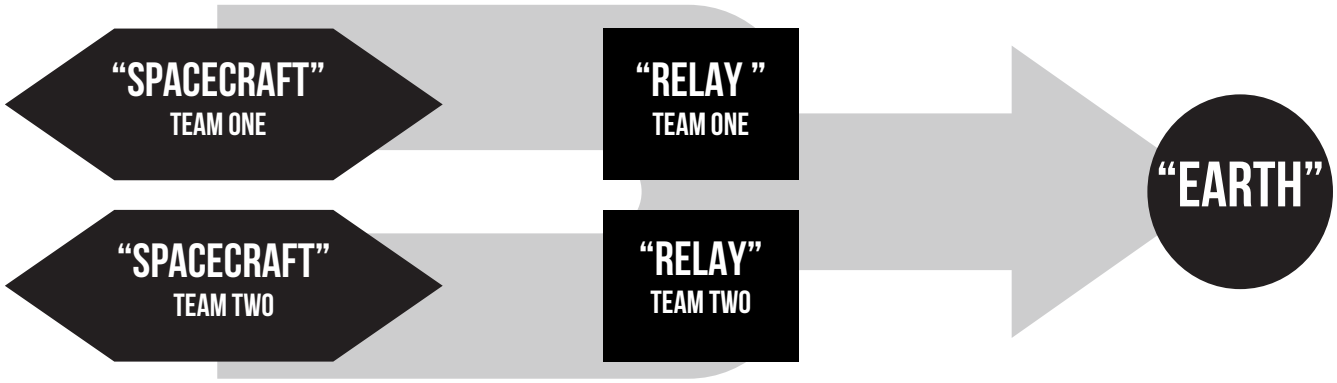
IF THE LAST MESSAGE SENT VIA	THEN THE NEW RESTRICTION IS	BECAUSE NASA MUST OVERCOME	EXPLAIN WHY
any form of sound	***NO SOUND*** *Note: This refers only to data transmission. Participants may use sound to plan their communication.*	vacuum	Sound is air molecules rubbing against each other in waves of vibrational energy. There's no air in space, so there's no medium through which sound can travel.
walking the message over	***NO LEAVING YOUR ZONES***	gravity	Reinforce that gravity is the force caused by *stuff* pulling on other *stuff*, and remind them that we have an enormous ball of *stuff* under our feet called planet Earth. Since they don't have rockets, they're stuck.
throwing / handing off	***NO HAND-OFFS*** ***NO THROWING***	gravity	Though redundant, restricting physical handoffs in two stages helps reinforce the idea of gravity wells. Give students the chance to toss crumpled notes / paper airplanes around. Additionally, throwing is failure-prone.
string can / telegraphs	***NO WIRES***	planetary motion, cost, distance, weight	Wires would be enormously heavy and expensive. Even if we could somehow build wires hundreds of thousands of miles long, planets are moving around! The wire would instantly snap. The landline concept is great on Earth, but doesn't work in space.
direct link to Earth	***NO LINE OF SIGHT***	planetary motion	Move the line-of-sight blockers into place so that Earth can't see the Spacecraft. With spinning planets, eclipses, etc., one can't always see one's target. This is why we made an entire constellation of relay satellites.
visual link	***NO SPELLING*** ***NO WRITING***	distance (part one)	Explain the distances involved (hundreds to millions of miles) and that we can't distinguish the lettering or visual signal.
telescopes / binoculars	***TOO FAR TO SEE***	distance (part two)	If someone suggests binoculars or a telescope, allow it for one round. Explain that NASA uses them all the time, but that the distances involved *still* make it difficult to see.
radios / cell phones	***NO RADIOS***	efficiency (size, weight and power limitations)	Walkie-talkies, cell phones, etc. all use radio frequencies to transmit data in invisible waves. While radio works well, it's slower, heavier and needs more power than optical communications, which use lasers. Time to find a more efficient solution.

RECOMMENDED WORDS

DUST	LUNA	WOW	FLY	SEND
NASA	SOL	DATA	LAND	ROCK
STAR	MARS	HOME	SEE	HI MOM
BEAM	WAVE	ATOM	SCAN	ION

ACTIVITY DIAGRAM

(ABOUT 32 x 25 FEET IS AN IDEAL PLAY SPACE)



MORSE CODE

A ●▬	G ▬▬●	M ▬▬	S ●●●	Y ▬●▬▬
B ▬●●●	H ●●●●	N ▬●	T ▬	Z ▬▬●●
C ▬●▬●	I ●●	O ▬▬▬	U ●●▬	
D ▬●●	J ●▬▬▬	P ●▬▬●	V ●●●▬	
E ●	K ▬●▬	Q ▬▬●▬	W ●▬▬	
F ●●▬●	L ●▬●●	R ●▬●	X ▬●●▬	

Traditional Morse code consists of short and long beeps conveyed electronically, sometimes voiced as 'dits' and 'daaahs.' Encourage your students to explore creative ways of implementing a binary system, and to consider techniques that use all of their senses.

EXAMPLE GRAPHICS

"EARTH"

"RELAY"

"SPACECRAFT"

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